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PROJECTING CROP YIELDS FOR THE UNITED STATES

CATALOGUING - PREP.

6501 by
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For presentation at Second Consultation of Experts on Problems
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INTRODUCTION

A revolution in farming methods occurred in the United States during the last two decades. Marked changes took place in the structure of United States agriculture, in terms of numbers and sizes of farms and in composition of inputs. Resource productivity increased by rapid strides. From 1940 to 1960, the volume of farm output rose by 55 percent while the acreage of land used for crops dropped 3 percent, and inputs of farm labor declined by nearly 50 percent.

Although the release of feed-crop acreage occasioned by the rapid shift from use of animal power to mechanical power on farms was a major source of greater output during the period, larger yields of crops became an increasingly important factor. For example, crop production per acre rose only 10 percent from 1940 to 1950, but from 1950 to 1960, it rose 33 percent.

During these two decades of rapid changes in farming, research workers in the United States Department of Agriculture and in the State Agricultural Experiment Stations made several projections of production possibilities of agriculture. These projections were estimates of what production was likely to be at some future date if certain specific assumptions and economic conditions prevailed.

With few exceptions, our projections failed to anticipate the rapidity of the changes in farming. Evidence indicates a tendency toward conservatism in gauging our production potential. Especially are we prone to underestimate potential increases in crop yields.

Projections of agricultural production possibilities serve many important functions. Such projections provide basic information for formulation of policies and programs for adjustments in agricultural production and resource use. They provide important guidelines for the programming of production research and the planning of agricultural extension activities. They are essential barometers for farmers, farmer organizations, and business firms that are closely allied to agriculture.

Because of the crucial role of projections of agricultural production, it is imperative that we take steps to improve the accuracy of such projections. A first step is to profit by past experience; to appraise critically the methodology we have used and to search for improved techniques of projecting. This is my chief purpose in this paper. I welcome this opportunity to appraise the projection work in which I have participated: I hope to profit by it. More important is my hope that the other participants in this Consultation may profit by this sharing of my experiences in the projection field.

My discussion will center chiefly on projections of crop yields and relate mainly to recent experience in projecting yields to the target date 1975. I shall address myself to the following specific topics, in the order in which they are listed.

First, will come a brief summary of experience with the 1975 projections.

The summary will include an examination of concepts, a description of methodology and sources of data, and an appraisal of the results of the projections.

Next, I will attempt a critical appraisal of the major factors that influenced the yield projections.

Finally, I will outline our tentative plans for further work on projections, including the nature of the research projects we hope will contribute directly or indirectly to greater accuracy of our projections.

THE 1975 PROJECTIONS 1/

A major objective of the 1975 study was to appraise agriculture's long-run capacity to produce. This appraisal was to serve as a guide for the programming of production research, and as a background for formulation of agricultural policies and farm programs.

In 1954 and 1955, projections of 1975 crop yields were made in a series of joint meetings of natural scientists and production economists of the Agricultural Research Service of the U. S. Department of Agriculture. In these initial meetings, yields of major crops were projected by States. In the period following 1955 crop yields rose rapidly. Because of this, in 1957-59, the yield projections for most of the crops were reappraised and adjustments were made, chiefly in the projections for the United States as a whole.

1/ For a detailed report of this work, see Rogers, Robert O., and Barton, Glen T., Our Farm Production Potential, 1975, U. S. Dept. Agr. Agr. Inform. Bul. 233, 1960.

Yield Concepts and Assumptions

Two levels of yield per harvested acre were projected for each major crop. The economic maximum yield relates to the yield that is possible from full, efficient economic application by all farmers of technology known at a given time under the economic and other conditions assumed. The economic attainable yield is what would be expected by 1975, from actual application by farmers of known technology. Thus, in projecting the latter yield, factors that influence the rate of adoption of technology by farmers were taken into account. Conceptually, this is the only difference between the two levels of yields.

The following major assumptions and definitions were used in making the projections:

- (1) The yield estimates were based on technology known at the time the projections were made. This is technology known by research workers or that which they believe will almost certainly be available to farmers by 1975.
- (2) Price-cost relationships among agricultural and other commodities approximating those prevailing in 1951-53 were assumed.
- (3) Average weather was projected for 1975.
- (4) The 1951-53 distribution of crops among land classes, areas, States, and regions was assumed to prevail in 1975.
- (5) Adequate quantities of fertilizer, machinery, and other production goods and services were assumed to be available to farmers.
- (6) Educational and other programs which encourage farmers to adopt improved production practices were expected to continue into 1975.

Procedures Used in Making Projections

A separate meeting of natural scientists and production economists was held to appraise yield possibilities for each major crop. The group of natural scientists usually included a representative from each of several research areas -- plant breeding, diseases, insects, soils, and so on.

At the outset of the meeting, the yield concepts and the various definitions and assumptions that were to underlie the projections were explained and discussed. Next, background material was presented and explained to the group. This material included tabulations of historical yields by States, yield potentials developed in other studies, the extent of irrigation of the particular crop, and the geographic distribution of acreage and production of the crop.

Working within the framework of the concepts, assumptions, and background material, the group first made estimates of economic maximum yields. At this point, the natural scientists made full use of their widespread knowledge of results of Federal and cooperative Federal-State research underway throughout the United States. These research results were discussed and evaluated in arriving at group estimates of economic maximum yields for each State.

The task of estimating economic attainable yields consisted of gauging the degree to which farmers might approach the level of economic maximum yields by 1975. Thus the assignment was essentially one of estimating the rate of adoption by farmers of known but as yet not fully used technology. This estimate took into account probable limitations on management, materials, equipment, and available capital, as well as past experience in farmers' rate of adoption of improved practices.

Appraisal of Projected Yields

Projected yields of 11 of the major crops included in the study are shown in table 1. Included also for purposes of comparison are average yields in 1951-53, the base period used in the study, and yields attained in recent years. In view of the rapid increase in yield levels in recent years, the 1975 projections for many of the crops appear to be quite conservative. This is especially true for corn, which is the major crop in the United States; it accounts for nearly 25 percent of our total crop production each year. Yields of corn in 1958-60 averaged 98 percent of the economic attainable yield projected for 1975. Thus practically as much increase in yield occurred in the 7 years from 1951-53 to 1958-60 as was projected for the 23 years from 1951-53 to 1975. In 1961, after allowing for the change in method of reporting, the average yield of corn was within 2 bushels of the economic maximum yield projected for 1975.

Grain sorghum presents a similar picture. The average yield of this crop in 1958-60 exceeded the 1975 economic attainable yield, and the yield in 1961 was 2 bushels greater than the projected economic maximum yield.

The relation between the projected yields and yields achieved in recent years varies among the other 9 crops shown in table 1. On the average, however, the level of economic attainable yields projected for all crops appears to fall short of that likely to prevail by 1975. In terms of an index of crop production per acre, the 1975 economic attainable yields average 138 (with 1947-49=100). On the same basis, the index of the economic maximum yields is 159. The index of crop production per acre averaged 126 in 1958-60, and reached a new record of 131 in 1961. The rise in crop production per

Table 1.- Yields of selected crops per harvested acre: 1951-53, 1958-60, 1961, and 1975 projected, United States

Crop	Unit	1951-53	1958-60	1961	1975 projections 2/	
		1/			Economic	Economic
					attainable	maximum
		:	:	:		
Corn, all-----	Bushel	38.7	52.0	3/ 60.5	53	61
Oats-----	do.	33.2	41.7	40.9	42	52
Barley-----	do.	27.8	30.0	28.8	35	42
Sorghum grain---	do.	18.0	38.5	43.9	35	42
Hay, all-----	Ton	1.43	1.69	1.71	1.83	2.13
Soybeans for beans-----	Bushel	19.9	23.9	26.2	26	30
Peanuts, picked and threshed---	Pound	925	1,186	1,230	1,357	1,877
Wheat, all-----	Bushel	17.2	24.9	23.5	24	27
Rice, rough-----	Cwt.	24.2	33.1	34.2	41	48
Potatoes-----	do.	147	178	189	208	276
Cotton-----	Pound	291	459	440	495	616

1/ Preliminary estimates in the October 1961 Crop Report of the Statistical Reporting Service, U.S.D.A.

2/ These projections were made initially in 1954-55; most of the yield projections were reviewed and revised in 1957-59.

3/ Relates only to corn harvested for grain. Yields for 1951-53, 1958-60, and 1975 are for all corn. In 1958-60, corn harvested for grain averaged 53.4 bushels per acre and all corn 52.0 bushels.

acre in the 9 years from 1951-53 to 1961 accounted for 80 percent of the increase in economic attainable yields projected for the 23-year period from 1951-53 to 1975. The actual increase during the 9-year period also closed 50 percent of the gap between production per acre in 1951-53 and that projected for the economic maximum yields.

What factors account for the apparent conservatism of our yield projections? A tentative answer to this question is the subject of the next major section of the paper.

MAJOR FACTORS INFLUENCING YIELD PROJECTIONS

Several factors may have influenced the projections of crop yields. It is impossible at this time to identify all of the factors, to say nothing of attaching a quantitative importance to each. Let us examine some of the major influences that may have contributed to bias in the projections. This examination can be made under three broad headings: (a) Determination of economic maximum yields, (b) determination of economic attainable yields, and (c) projection of the pattern of crop acreage.

Economic Maximum Yields

As defined, the economic maximum yields were intended to be measures of the full yield potential of each crop under the economic conditions and other framework assumed in the study. More specifically, this potential was based on the technical knowledge existing at the time the projections were made. Thus the estimates of economic maximum yields were intended to provide specific ceilings on the projections of economic attainable yields.

The concept of economic maximum yields used fails to provide for any influence on future yields of unknown or as yet undiscovered technology. Assuming that we will continue to add to our store of technical knowledge in the years ahead, this concept has a built-in downward bias for purposes of yield projection. This bias was recognized at the outset of the study, but because of our inability to develop effective techniques for projecting future research results, it was rationalized.

The downward bias inherent in the concept of economic maximum yields becomes larger as the length of the period for which yields are projected increases. This bias in our yield "ceilings" is of little importance, however, in explaining the apparent conservatism of our projections when 1975 yields are compared with recent yield achievements. In the United States, it is generally recognized that a period of 10 to 15 years elapses between the beginning of most research projects and any extensive use by farmers of the research results. It is much less than 10 years since the 1975 projections were made. In fact, reviews and revisions of the yield projections for most of the major crops were made less than 5 years ago.

There are other sources of error in the estimates of economic maximum yields. The first relates to the nature and use of the basic data available for making the estimates. These data consisted chiefly of experimental results with which the natural scientists were familiar. Unfortunately, from the standpoint of work on projections, few of the experiments were designed to provide data on the crop yields that would result from use of the best combination of known, improved crop practices. Rather, most of the experiments had more restricted objectives, such as testing of the relative

merits of varieties of a crop with other inputs and practices held constant at a level that might approximate current practices of farmers. Consequently, it was possible for large errors to occur when judgment was used in estimating the yields that would result from combinations of improved crop practices.

Large errors could also have resulted from inability to use data available from yield experiments in making estimates consistent with the concept of economic maximum yields. This estimation involved judging the extent to which it would pay a farmer to adopt improved practices.

A further problem arose from the necessity of translating crop yields obtained under experimental conditions into yield levels that could be expected under actual farming conditions. Difficulties were involved also in accounting for effects on yields of variation in soil classes. The design of many of the experiments from which basic data on yields were obtained did not closely approximate actual average farming operations and conditions.

A difficult task and possible source of major error was the estimation of the economic maximum yields to be expected with "average weather." This involved judging the impact of weather on experimental yields. It called also for a judgment appraisal of the effect of weather on average yields obtained by farmers at the time the projections were made. Unfortunately, we do not yet have an objective and satisfactory means of adjusting crop yields for weather variations.

It is possible that the various errors involved in estimating economic maximum yields were compensating. We have no firm basis for asserting that these estimates are either too high or too low. In view of recent yield experience, however, I suspect that our appraisals of yield potentials are

conservative. Of one conclusion I am certain: If we are to improve the accuracy of our yield projections, we need a more objective basis for ascertaining yield ceilings, given present or prospective technology. If we accomplish this objective, we may need to abandon the concept of economic maximum yield used in our study. A possible substitute will be discussed later in this paper.

Economic Attainable Yields

Errors made in estimating economic maximum yields, in turn, would have introduced some degree of error into the estimates of economic attainable yields because of the relationship between the two yield concepts. However, given the level of economic maximum yields, the major source of error in estimating economic attainable yields is the inability to gauge the speed with which farmers will adopt known but unused technology.

First, let us look at the influence of economic incentives on rate of adoption of technology. Price relationships existing in 1951-53 were assumed for our projections. The parity ratio, or ratio of the index of prices received by farmers to the index of prices paid by farmers, averaged 100 in 1951-53. Since this period, the parity ratio has trended downward markedly and is now around 80. Obviously, this decline in the relative terms of trade for agriculture is a departure from our economic assumptions and could be expected to retard the rate at which farmers adopt improved practices.

Actually, during the 1950's, farmers increased their crop yields substantially and adopted improved practices rapidly, despite a decline in the parity ratio. That this was rational is evident when we examine the economic structure of United States agriculture.

No farmer can affect prices received for his commodities through his own production decisions. However, with a reserve of unused technology available, most farmers found it profitable to adopt improved practices, such as greater use of fertilizer. This means of lowering unit costs and increasing production on their farms was available to farmers as individuals and was subject to their decisions.

Numerous studies of profitable adjustments on representative farms in the United States have shown that there is a powerful economic incentive for farmers to adopt improved practices even with relatively unfavorable price-cost relationships. Barring disastrously unfavorable price-cost relationships, this economic incentive will continue to induce farmers to increase yields of crops so long as a reserve of unused technology is available. Apparently, in our projections of economic attainable yields we underestimated the emerging power of this force.

Another major factor influencing rate of adoption has been changes in the level, or quality, of farm management. "Management" is difficult to measure quantitatively. Nevertheless, when we consider the marked changes that have occurred in the structure of agriculture, there can be no doubt of a rapid upgrading of management in U. S. agriculture in recent years. For example, the total number of commercial farms dropped by 0.4 million, or 10 percent, between 1949 and 1954. From 1954 to 1959, however, the number decreased 0.9 million, or 28 percent. More importantly, the number of commercial farms of family size reporting \$10,000 or more of marketings increased by one-third in the earlier period and by more than one-half from

1954 to 1959. 2/ Supporting this means of upgrading of management was the accompanying trend toward specialization of production. Fewer enterprises per farm simplified management in many respects.

The acceleration of the trend toward a greater number of farmers with improved management skills and fewer but larger family-sized commercial farms suggests that management decisions in United States agriculture are rapidly becoming concentrated in the hands of farmers who tend to adopt improved farming practices and who are in position to acquire the credit and capital needed to change their farming methods. In my judgment, this change in the management picture, coupled with the economic incentives noted previously, accounts largely for the sharp rise in crop yields in the United States in recent years. Again, in our projections, we apparently failed to anticipate the rapidity and importance of the imminent structural changes in agriculture and of the improvement in management skills.

Difficulties inherent in judging the impact of weather on crop yields are also a possible source of error in projecting the rate and degree of adoption of improved practices by farmers. Errors are possible on two scores. First, in projecting economic attainable yields to 1975, the level of current yields adjusted for weather in effect served as a lower limit in the same sense that the economic maximum yields served as a ceiling, or upper limit. Consequently, any tendency to overdeflate current yields for weather, for example, would contribute to a downward bias in the projections of 1975 economic attainable yields.

2/ These data are the result of recent research by R. Nikolitch of the Farm Economics Division, Economic Research Service, U.S.D.A.

The use of past trends in yields as gauges for future rates of adoption also involved implicit assumptions regarding the effects of weather on historical yields. Thus, any tendency to overemphasize the contribution of good weather to the level of current yields would contribute to downward bias in projections of future increases in yields. It seems likely that good weather may have been overemphasized in the process of estimating many of the 1975 economic attainable yields.

Acreage Pattern

As noted earlier, the pattern of crop acreage of 1951-53 was assumed in making the 1975 projections of yields. Departures from this assumption can affect the level of yields actually attained.

Changes in the distribution of acreage of an individual crop among regions, States, and smaller areas can raise or lower the yield of the crop owing to differences in yield levels among the geographic units. Similarly, even on an individual farm, the yield of a given crop can be varied because of a farmer's decision to concentrate the crop on acreage of higher or lower productivity.

Marked changes in acreage of individual crops have occurred since 1951-53. For example, the acreage of sorghum grain has more than doubled and the area devoted to soybeans has increased almost as rapidly.

Shifts in the distribution of acreage among crops can affect total crop production even though yields of the individual crops show little change. Changes in acreage of oats provide a good example. Oat acreage has dropped by about one-fourth since 1951-53. Such crops as soybeans have replaced oats. This has raised average production per acre, as soybeans yield about

twice as much per acre as oats in terms of constant-dollar value of production. In the final analysis, we are more concerned with projecting crop production per acre than with projecting individual crop yields per se. 3/ Consequently, we need to improve our techniques for projecting changes in the acreage pattern.

Many forces have influenced the cropping pattern in the last decade. These include Government programs to adjust acreage, technological forces, a trend toward greater specialization, and the combination of factors that gives comparative advantage in production to one region or another. The net result of all these forces on changes in yields and crop production per acre is difficult to appraise. It is probable that, in total, they have contributed to the rise in crop production per acre. However, it is doubtful whether they are a major factor in explaining the apparent conservatism of our projections.

PLANS FOR IMPROVING PROJECTIONS

Projections of crop yields play a key role in many of the research and service activities of the U. S. Department of Agriculture, and there is a regular demand for analyses of this kind. Projections must be made when needed. Consequently, this precludes delaying work on projections until we have results of research currently underway or in the planning stage. It may be of interest, therefore, to describe and appraise the methods we are now using to project crop yields.

3/ For an analysis of past effects of changes in composition of acreage on crop production per acre, see Durost, Donald D., and Barton, Glen T., Changing Sources of Farm Output, U. S. Dept. Agr. Prod. Res. Rpt. 36, 1960.

Current Projection Methods

The projections with which we are usually concerned are for two time periods: (a) 5 to 10 years ahead, and (b) 20 to 30 years ahead. We have decided to place heavy reliance on the use of extrapolations of the U. S. trend in yields during the 1950 decade as a major basis for projecting yields over both the shorter and longer periods ahead. This decision rests on two premises. First, we feel that use of the estimates developed earlier in cooperation with scientists of the Agricultural Research Service resulted in too conservative projections with the approaches used. Also, we feel that the size of the available reserve of technology, plus prospects for additions to this reserve, are such as to permit yields to trend upward at a rate approximating that in the last decade. Prospects for continued strong economic incentives to individual farmers and almost certain further changes in the structure of agriculture, which were discussed previously, support the assumption that farmers will continue to adopt unused technology at a rapid rate.

Although the decision to depend heavily upon trends of the 1950's as a basis for yield projections is defensible, especially for the shorter period ahead, I hope that we can soon develop a more satisfactory alternative. Trends can be a fickle device for projecting, as the results are highly dependent upon the selection of the time period for which a trend is fitted.

The vagaries of trend projecting can be illustrated by considering this technique as an alternative to the approach used in the 1975 study. If at the time this study was initiated in 1954-55, we had fitted a linear, least squares trend to the index of crop production per acre for the period

1940-54, and extrapolated to 1975, the index would have been 121. Similar use of a trend for the immediately preceding decade 1944-54, would have resulted in a 1975 index of 114. As noted earlier, the index consistent with the estimates of 1975 economic attainable yields is 138, which compares with indexes of 126 and 131 in 1958-60 and 1961, respectively. In this instance, trend projecting would have fallen far short of the mark and would indeed have been conservative!

We are not complacent about the use of trends in our projection work. What then, are the alternatives? Some clues are given in the section that follows in which I will describe some of the research we have underway or plan to initiate.

Contributing Research

One line of research, which was recently initiated, gives promise of eventually contributing materially to the projection work. This year we completed a pilot study, the chief objective of which was to develop a measure of the effect of variation in weather on crop yields. 4/ Corn yields in the State of Iowa over the period 1929-60 were selected for study. Basic data were the yields obtained by farmers who cooperated with natural scientists in variety research in the 12 Iowa Corn Yield Test districts. The following major features of these basic data may be noted:

(a) The variety yield tests were conducted under actual farming conditions. Except for actual planting of the seed and hand harvesting of the crop, which were done by research workers, the test plots were farmed in the same manner as the other corn of the cooperating farmers.

4/ This research is being conducted by Lawrence H. Shaw and Donald D. Durost, Farm Economics Division, Economic Research Service, U. S. Department of Agriculture.

(b) The test plots were subject to some experimental control and measurement. This included a widespread geographic dispersion of plots within the State.

(c) By virtue of their willingness to cooperate, it can be assumed that the farmers who conduct the tests generally are "leading farmers" in the sense that in growing their crops, they are prone to take advantage of most of the currently available improved practices. When compared with average yields obtained by all farmers in Iowa, their yield achievements support this assumption.

By using moving averages and other statistical techniques, it was possible to estimate yields which the cooperating farmers would have obtained each year with average weather. Ratios of actual yields to these "trend" yields provided an index of effect of weather on corn yields in each of the 12 districts; these, in turn, were combined into an index for the State as a whole.

The pilot study thus results in two sets of data that can be used to advantage in projection work. The indexes of effect of variation in weather permit adjustment of historical yields obtained by all farmers. This enables us to visualize more accurately the net result on yields of farmers' past adoption of improved practices, and hence gives a better clue regarding future possibilities.

Perhaps of even greater importance, the "trend" yields obtained by farmers cooperating in the variety tests may provide a practical and fairly objective substitute for the economic maximum yields developed in the 1975 study. We could extrapolate yield trends of recent periods with greater

assurance if data on yields achieved by leading farmers were available to serve as ceilings and checks on the extrapolations.

Preliminary results of the pilot study for Iowa give a clue regarding the merits of the weather-adjusted yields obtained by the cooperating farmers. These yields of corn in recent years have averaged well over 100 bushels per acre. In the initial meetings with the natural scientists of the Agricultural Research Service, an economic maximum yield of 90 bushels and a 1975 economic attainable yield of 80 bushels were estimated for the State. 5/ Current reports of the Statistical Reporting Service, USDA, indicate that in 1961, Iowa farmers will harvest 73 bushels of corn per acre.

We plan to devote research resources to an extension of the work initiated in the pilot study for Iowa. Future results of such efforts should aid materially in our projection work.

We have made some progress also in another promising area of research. Thus far, this effort has consisted of two attacks on the problem of projecting rate of adoption of improved practices by farmers. 6/ First, study of the relation of changes in crop yields and associated major inputs, such as fertilizer, to changes in numbers and sizes of commercial farms in various regions is underway. The second activity involves the mathematical fitting of growth curves to farmers' extent of use of such things as hybrid seed, tractors, and specialized machines. From this research, we hope to

5/ These estimates, in effect, were later lowered when the corn projections were reviewed and adjustments were made in the yields for the United States as a whole.

6/ This research is being conducted by Dr. Alfred L. Barr, Farm Economics Division, Economic Research Service, USDA.

get a better understanding of the time path of adoption of innovations by farmers. We hope also to generalize our results by regions, types of innovations, and changing patterns of adoption rates over time. Preliminary results of the research substantiate the fact that United States farmers are speeding up their rate of adoption of improved farming methods.

We need to study past changes in the acreage pattern of crop production in the United States and the major factors associated with these changes. Although no specific research on this subject is currently underway, we plan to initiate work when research resources become available for it.

Successful projection of crop yields involves ferreting out the net results of many complex and interrelated economic, institutional, and technological forces. Consequently, we intend to make full use of any research results that can aid in our projection work. This will include use of the widespread studies of profitable adjustments in farming conducted by the Farm Economics Division, Economic Research Service, in cooperation with State Agricultural Experiment Stations. Effective use can eventually be made also of the results of further studies having to do with analysis of spatial equilibrium and farmers' production responses in major type-of-farming areas. 7/

7/ For an example of the spatial equilibrium technique, see Egbert, A. C., and Heady, E. O., Regional Adjustments in Grain Production - A Linear Programming Analysis, U. S. Dept. Agr. Tech. Bul. 1241, 1961, Iowa Agriculture and Home Economic Experiment Station, Center for Agricultural and Economic Adjustment cooperating. The major features of a new method of analyzing production response are described in "Recursive Programming and Supply Prediction," by Richard H. Day, published in Agricultural Supply Functions, Iowa State University Press, Ames, Iowa, U.S.A., 1961.

CONCLUDING OBSERVATIONS

In closing, I want to make a few additional comments. First, although they are of basic importance, we all recognize, I'm sure, that projection of crop yields is only part of the larger task of appraising the production problems of agriculture in the years ahead. Difficulties are encountered also in projecting the future course of livestock production and the changes imminent in the efficiency of feed conversion by livestock. Similarly, population growth and spreading urbanization underscore the increasingly important role that projections of utilization of land and water resources will play in our attempts to look ahead. Certainly, our job will not be complete unless we appraise also future changes in resource use and factor productivity in agriculture.

Second, so that there may be no misunderstanding of terms, I want to emphasize a subtle but I believe, important, distinction between "projections" and "forecasts." In our work, we need not be concerned so much with what production will actually be at a given future date (forecasting), but with what production may be if certain specific assumptions, including a given economic framework, prevail at the future date (projecting). Thus, we can develop sets of alternative projections. By so doing, we may be better able to point out well in advance the nature and magnitude of emerging economic problems -- a chief function of successful projections. A measure of the degree of our success as projectors will be our ability to account, in retrospect, for departures of projections from actual fact in terms of the failure of our assumptions to hold.

Finally, I want to comment briefly on my frequent references to judgment estimates in connection with appraisal of the 1975 study. This was not intended as an indictment of our projection work. Nor was it intended as a reflection on the ability or integrity of our colleagues in the Agricultural Research Service. We will want to work closely with them in the future as in the past. Rather, my intent was to emphasize the need for better and more pertinent data that will provide a more objective basis for using the judgment of both natural scientists and production economists. (Perhaps someday we will be blessed with such a wealth of data, econometric models, and facilities for electronic computing that projecting can become a "push-button job.") However, I predict that for a long time to come the science of projecting, in practical application, will be flavored strongly with judgment estimates.

